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Continuous wavelength-tuning across the visible spectrum with a compact and inexpensive liquid crystal laser

Continuous wavelength-tuning across the visible spectrum with a compact and inexpensive liquid crystal laser

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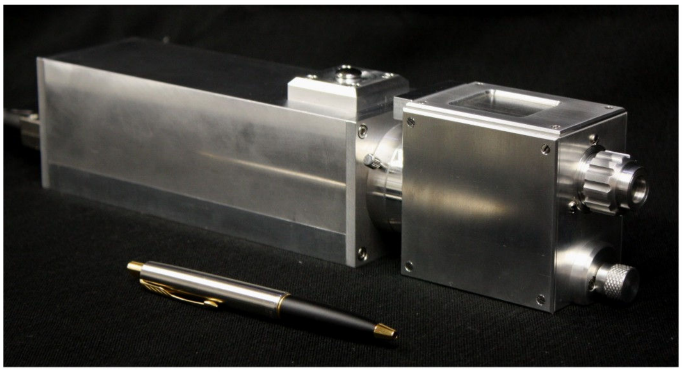
We report on the latest research in the field of band-edge lasing from dye-doped chiral nematic liquid crystals [1]. Specifically we have developed a portable liquid crystal laser demonstration unit, capable of continuous wavelength-tuning across the visible and near-infrared (450 to 850 nm), within a highly compact and simple device architecture, and with slope efficiencies greater than 60%. It is anticipated that from this technology a new generation of small and inexpensive tuneable laser sources may be produced, which may find particular applications in portable (and ultimately hand-held) fluorescence-based medical diagnostics tools, such as Raman spectroscopy, confocal microscopy, or flow cytometry.



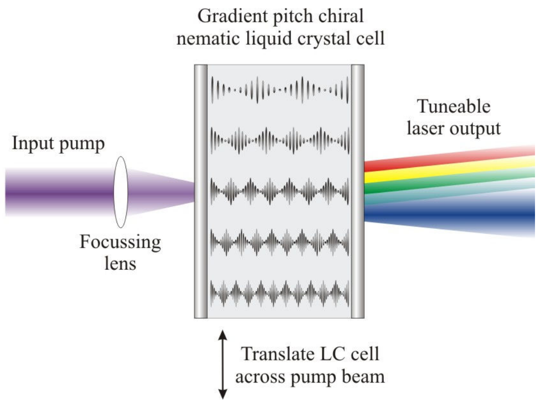


Fig.1. (Left) the COSMOS tuneable liquid crystal laser demonstration unit, and (right) the mechanism for colour tuning using gradient pitch chiral nematic cells.

The construction of a liquid crystal laser is described. Nematic liquid crystals are doped with chiral twisting agents and organic dyes. The chiral dopant controls the degree of twist of the liquid crystal, and is used to vary the selective reflection from the photonic band-gap structure. The band-edge is then chosen to match the fluorescence maximum of the organic dye, maximising the density of photonic states at the long band-edge, and increasing the probability of lasing. Mixtures are then filled into 10 micron glass cells with antiparallel-rubbed alignment layers. When optically excited with a suitable pulsed pump beam (at a wavelength matching the absorbance of the dye), a divergent beam of circularly-polarised laser light is emitted from the device, normal to the plane of the cell. Wavelength tuning of the liquid crystal laser is achieved through the use of gradient pitch chiral nematic cells [2]. Two different lasing mixtures are prepared; one with a short chiral pitch and dyes optimised to lase at the blue end of the spectrum, and the other with a longer chiral pitch and dyes optimised to lase in the red. The two mixtures are simultaneously filled by capillary action into the cell from opposite sides, and allowed to diffuse together forming a pitch gradient. Diffusion can be halted through polymer stabilisation techniques, enabled through the addition of a small quantity of optically-curable polymer. The gradient pitch cells are then mechanically translated across the pump beam to produce continuously tuneable laser emission over the visible spectrum. Analysis of the variation in efficiency and threshold across the device at different wavelengths is presented, along with suggested improvements for future development.

References:
[1] H.J. Coles, S.M. Morris, *Liquid crystal lasers,* Nature Photonics, **4**, 676 (2010).
[2] S.M. Morris, P.J.W. Hands, S. Findeisen-Tandel, R.H. Cole, T.D. Wilkinson, H.J. Coles, *Polychromatic liquid crystal laser arrays towards display applications,* Optics Express, **16** (23), 18827 (2008).

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